Do we know the way now? Using international comparison to confirm a policy package that can deliver energy savings from appliances

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Abstract

What are effective packages of policies and measures to stimulate energy efficiency from appliances? In the project "bigEE – Bridging the Information Gap on Energy Efficiency in Buildings", we have addressed the question in a systematic way – by combining theoretical evidence on what policy support markets need, and an international comparison on which packages of policies have worked well. The project develops an international internet-based knowledge platform for energy efficiency in buildings (www.bigee.net). Hence, it must provide evidence-based information.

On the theoretical side, presented in earlier papers, the analysis starts with the barriers but also market-inherent incentives that the different types of market participants face. This enables to identify, which regulatory, economic and other policies and measures need to be combined to overcome barriers and strengthen incentives. On the empirical side, model examples of good practice for policy packages have been collected and their design and impact compared. Finally, the model examples, lessons learned, and the preconditions for their transferability are used to validate the generic policy package identified in the theoretical analysis.

In this way, we were able to support the well-known recommendable policy package for appliances, combining MEPS, mandatory energy labelling, and information of consumers and training of sales staff, financial incentives where appropriate, and measures to stimulate innovation and market introduction such as award competitions and public or co-operative procurement, with fresh evidence. The paper will present the recommended package as well as a comparison of existing national policy packages from Brazil, China, Japan and California (USA) and what we learned from it for effective packages and implementation.

Introduction

Policy-makers worldwide have increasingly recognised energy efficiency as a key factor to reduce the energy consumption and to realise a sustainable energy future. In this context, appliances, as a major source of energy use should be a focus to control the energy consumption and to reduce greenhouse gas emissions. The most energy-efficient appliances available today can save between 60% and 85% of energy compared to inefficient models that are still on sale in many countries [19]. The energy efficiency efforts do not only achieve high energy saving potentials. CO_2 emissions can also be reduced cost-effectively from a life-cycle perspective and thus provide economic benefits. Furthermore, a policy package that concentrates on the whole life-cycle of the product can address other sustainability aspects like other resources and health aspects and realise several co-benefits like an increased competitiveness. By offering innovative products this can open up new (niche) markets, which will likely have a positive effect on the economy as a whole [8].

Yet, at least as many papers have concluded that in spite of their cost-effectiveness, these savings are not going to be realised by market forces alone (e.g., [11]; [15]). This lack of market uptake results from a large variety of barriers and market failures that hinder market actors to manufacture, sell or buy energy efficient products [18].

Therefore, the challenge remains to reach all relevant target groups and to transform the appliance sector in a way that efficient solutions will no longer be an exception but become the standard choice of market actors. We have to abandon the prevailing 'as-fast-and-cheap-as-possible' construction approach, because it systematically ignores lifecycle costs and creates appliances that will be wasting enormous amounts of energy and money throughout their whole lifetime [15].

To reach this goal, actor-specific and well-designed packages of policies are required. Policy-makers should be encouraged and informed to combine a selection of instruments tackling the most important market barriers.

The web-based platform "bigEE.net - Your guide to energy efficiency in buildings" was developed to make structured information easily available and to enable policy-makers to make well-considered decisions. The demonstration of the practicability of different policy approaches and the successful implementation can be a key motivation for policy makers to transfer a similar policy or to improve existing ones. The project seeks to address this problem by summarising knowledge and presenting comprehensive, independent and high-quality information on energy efficiency in buildings and appliances on its international website. In particular, the project aims to make the information about existing policies and technologies throughout the world comparable and present it in a targeted way so as to support investors and policy makers in making the right – energy-efficient – choices.

Many studies (e.g. [7]; [15]; [17]) have argued that different types of policies – most notably regulation, financial incentives and information, or "the sticks, the carrots, and the tambourines" – need to be combined into packages in order for them to be effective and make energy efficiency easy and attractive for market actors. However, we are not aware of a systematic and comprehensive analysis to underpin and derive what kind of policies and measures the packages should consist of, and how they need to interact.

To develop the evidence-based information required for bigee.net, we addressed in a different way than usual the question of how policy can support improved appliance energy efficiency most effectively: We combined (1) a theoretical, actor-centred analysis of market-inherent barriers and incentives for all actors in the supply and use chain of (energy-efficient) appliances to derive a recommended package combining the types of policies and measures the actors need to overcome all these barriers, with (2) empirical evidence on model examples of good practice policy packages to check if pro-active countries have indeed used the combination of policies we derived from the actor-centred analysis. While the actor-centred analysis has been presented during the EEDAL conference 2011, this paper focuses on the empirical evidence.

In the paper, we will therefore briefly describe the bigEE project to illustrate the project background and its scope. Next, the methodological approach to developing the recommended policy packages for energy efficiency in appliances will be presented. Then follows the resulting strategic package approach to energy efficiency policy for energy efficient appliances, proven in practice by a comparison of the existing national policy packages from California (USA), China, Japan, and Brazil.

bigEE – Your guide to energy efficiency

"bigEE – bridging the information gap on energy efficiency in buildings" is a project by the Wuppertal Institute, with financial support from the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Within the project, the international internet-based knowledge platform "bigEE – Your guide to energy efficiency in buildings was developed (see: www.bigee.net). Three comprehensive guides – for building design and technologies, for appliance energy efficiency and for policy implementation present detailed information about how to increase energy efficiency and how policy can support this development. Apart from information universally

applicable for policy makers and investors from all over the world, up to five partner countries will be addressed, starting with China and South Africa and possibly soon Mexico.

A central task for bigEE is collecting and updating information on the best available technologies (BAT) on a comparable basis, as well as the gathering of possible energy saving potentials (depending on different scenarios and market developments) and their net economic benefits, and the demonstration of successful implemented good practice policies. To achieve the required quality of information, the bigEE team collaborates with scientific institutes and with existing initiatives (international and in partner countries) including the United Nations Environment Programme (UNEP) and the International Energy Agency (IEA). Furthermore, bigEE engages in the active dissemination of information relevant for policy-makers in the partner countries.

Methodology[1]

Different steps are needed to derive an 'ideal' policy package, which increases the energy efficiency of appliances and which assist the various actors in overcoming their specific barriers and strengthening their incentives. Experience from pro-active countries and an analysis of market barriers show that several instruments will need to interact and reinforce each other in a comprehensive policy package. The question we have to answer then is which specific policies and measures should be combined in strategic policy packages to address the barriers and incentives, and how they need to interact. We used a two-step approach combining (1) an actor-centred theoretical analysis with (2) an empirical proof.

The methodological approach we use on the theoretical side is based on and seeking to extend and refine the theory-based policy evaluation approach, which goes back to experiences with energy efficiency policy evaluation in the USA (e.g., [2]) and was applied and developed further more recently within the EU project AID-EE (cf. www.aid-ee.org). Originally, the theory-based approach was developed for ex-post evaluation of existing policies. It aims at understanding how policies work and the factors of success or failure by defining for each step of implementation a theory on the implementation mechanism or strategy of the step and indicators to measure success of the step and the instrument overall. It can be used both for process evaluation and for theoretically explaining the reasons for the impact achieved – success or failure. The AID-EE project has pointed out that this can also be used to examine ex ante whether policies are expected to be successful, and therefore guide policy design. In bigEE, we developed this further to analyse, which implementation strategies and policies need to be combined to a package to achieve success in realising energy efficiency.

The actor-centred theoretical analysis starts with the identification of all relevant market actors along the value chain of the national market for the type of appliance concerned. In order to be able to adequately design and implement energy efficiency policies and measures, political decision makers must have good knowledge of the concerned market actors and thoroughly analyse the specific incentives and barriers faced by each of them. These market actors are for instance manufactures, whole sales, retailers, investors and users. All of these actors make decisions that can influence the energy performance of appliances in question.

After identifying the relevant actors in the appliances market, it is necessary to put the focus on the actor-specific barriers and incentives. All actors have some inherent incentives to develop, offer, demand or invest in energy-efficient solutions, but are on the other hand facing strong barriers that prevent them from choosing energy efficiency [6]. The challenge is to identify the reasons that cause actors to be inclined towards or to refrain from choosing low-energy appliances - these barriers are the major reason why there is a gap between potential and realised energy savings. Each actor group has its own characteristics and therefore every policy has to pay attention to these. By knowing the barriers and incentives the policy package can be adapted to guarantee desired results and achieve the greatest possible success [15]. Barriers are for example the lack of knowledge and motivation, the high search and transaction costs, the uncertainty about the related monetary and other benefits,

[1] The actor-centred analysis was already published during the EEDAL conference 2011 (see [14]). For a detailed analysis of this theoretical approach please refer to this paper of visit www.bigee.net

capital constraints, the investor-user barrier or technical barriers. In comparison to these actor-specific barriers several incentives can be identified like saved energy costs, the increased (re-sale) value of the appliance or the contribution to environmental protection. The relevance of some of these barriers and incentives may differ from country to country depending on national circumstances [6]. Two questions remains:

- How can the immanent incentives that market actors have be strengthened?
- How can the specific barriers that market actors face be overcome?

In this context policy is needed to overcome the respective barriers and to exploit the existing potentials. For policy makers it is essential to identify the different barriers and incentives and to develop appropriate remedies in the form of tailored policy packages, which aim to remove the barriers and strengthen the incentives identified [6]. The overall goal for policy makers should be to move the market towards to the best available technology and to the best not yet available technology (BNAT) with very high energy efficiency levels. There are a number of direct ways to target the barriers and incentives. This ways can be called implementation strategies. By way of addressing the actor-specific incentives and barriers, these strategies aim to make energy efficiency feasible, easy, and attractive, and eventually even the default (i.e., the behavioural norm or even the legal standard). An implementation strategy may act on several incentives and barriers. Some examples for these implementation strategies are:

- Bring down the first costs of energy-efficient appliances via market transformation or economics of scale
- Increasing motivation by making it as easy as possible to choose the energy efficient option – make appliance energy consumption and quality visible and comparable; use social marketing tools
- Improve access to capital, e.g. subsidize purchase of energy- efficient appliances, establish innovative financing mechanisms

As a next step, political decision makers but also non-governmental actors such as energy service companies must take concrete measures and enact actual policies in order to put the implementation strategies to work. For each of the implementation strategies, a package of policies and measures is needed to make it work, and since also a combination of implementation strategies is necessary to tackle the manifold barriers, these targeted policy packages must then be merged into a consolidated overall package, which is ultimately capable of kick-starting a real market transformation in the appliance market. It is essential to have a look at the technology and the product-specific potential and to demonstrate the best way to increase energy efficiency with a package of different but coordinated instruments. Some instruments are alternative to each other, but usually several instruments should be coordinated in an adequate policy package to establish synergy effects and realise the implementation strategy.

The strategic policy package to deliver energy efficiency in appliances

According to international research and experience, a package of several types of consistent and technology-specific and actor-specific policy instruments is useful to be most successful. Instead of a single instrument, a package offers the opportunity to achieve synergies between single instruments, and to reach all market actors [15]. The ideal policy package consists of consumer-oriented instruments and instruments for manufacturers (to build a “push and pull strategy” to push consumers and manufacturers away from energy intensive practices and to pull them towards energy efficient ones). Each policy is tailored to overcome one or a few certain market barriers and to strengthen the actor-specific incentives, but none can address all of these barriers and incentives. Therefore, the impact of well-combined policies is often larger than the sum of the individual expected impact [7].

Different policies addressing the demand-and supply-side actors of markets should consequently be properly combined according to national circumstances. This does not mean that governments seeking to improve the energy efficiency of appliances have to implement all possible policies in order

to be successful, but they should combine a selection of instruments tackling the most important market barriers.

As our analysis has concluded and successful countries have demonstrated (cf. also Table 1 below), a comprehensive and coherent policy package for energy efficiency in appliances will usually provide a sound balance between clear mandatory measures, incentives, information and capacity building. It also needs a governance framework to enable implementation of these policies.

The presentation starts with this overarching governance framework for energy efficiency that is general to appliances. Afterwards, the specific parts of the package with concrete policies and measures for energy efficiency in appliances follow suit.

The governance framework for energy efficiency

In the bigEE recommended policy packages, the general governance framework serves to guide and enable implementation of the sector-specific policies, as well as to remove price distortions in energy markets that would make energy efficiency improvements appear less cost-effective than they are.

A Policy Roadmap with a clear timetable and targets will guide policy-making and signal to the market a reliable political support for energy efficiency. The targets should be: Prepare markets for mainstreaming highest energy efficiency levels.

The administrative infrastructure and the funding for the other policy elements need to be in place. This includes (1) an energy agency or similar institution for co-ordinating activities. To ensure (2) stable funding, government energy efficiency funds and/or energy companies with the task to achieve energy savings via energy efficiency programmes are also required.

Energy prices should ‘tell the economic and ecological truth’. In addition, they must also consider social issues and should encourage energy sufficiency. It is essential that subsidies for energy production or on energy prices be gradually removed - governments are advised to rather use the budget saved to fund energy efficiency schemes for low-income households, so as to keep energy bills affordable instead of keeping energy prices artificially low. In addition to removing energy subsidies, energy or CO_2 taxes will finally internalise environmental damage and threats to health into final energy prices.

How the specific policies and measures for energy efficiency in appliances interact

For energy efficiency in appliances, the appliance-specific instruments can be packaged as follows:

- Mandatory minimum energy performance standards (MEPS) are the most important policy for energy efficiency in appliances. They should be created by law and then strengthened step by step every three to five years, to finally require energy efficiency levels equivalent to very energy-efficient appliances. MEPS reduce transaction costs as well as the landlord-tenant and buyer-user dilemma by removing the least energy-efficient models from the market. They should, however, always be at least as stringent as the energy performance level leading to least life-cycle costs. In a transition period before a law can make MEPS mandatory, a voluntary standard may help. Preferably, other statutory requirements, such as individual metering, would complement the legal framework.

- Energy labelling works together perfectly with energy performance standards. MEPS usually eliminate the worst products from the market but do not harness additional energy-saving potentials. Energy labels present the best products on the market and are primarily made for buyers and end-users. They are, thus, one element of the package to “reach the energy efficiency top”, like the others that follow here. Mandatory energy labelling schemes mostly compare the products on a classification scale to show the best but also the worst products on the market. Such classification labels are, however, useful only if there is a large enough spread of energy efficiency levels between the models of a type of appliance offered in a market. Where that is not the case, an endorsement label for the most energy-efficient

models only may be an alternative. Furthermore, an information campaign is needed in order to promote the label and to raise the consumers' awareness towards energy efficiency.

- The market should, furthermore, be prepared for the next step(s) of MEPS regulation towards very efficient appliances through policies tackling the substantial information deficits and financing barriers. This includes the already mentioned energy labels, but also advice, easy-to-use product choice and life-cycle cost calculation tools. Policies for consumers should be designed to address specific actor groups but also the broad public. Highly consumer oriented approaches can bring energy efficiency on the agenda for many actors like end-users and investors (e.g. by TV spots or included in the school curriculum). Such programmes can address the rebound effect. These effects occur when consumers buy bigger and bigger appliances, such as large televisions of refrigerators or when they improve their desired thermal comfort (e.g. higher indoor temperatures in cold seasons). Policymakers should try to limit these rebound effects e.g. through motivation and information campaigns on energy-efficient user behaviour.
  Financial incentives - such as rebates, grants and tax incentives – can guarantee a broad market introduction of energy-efficient appliances. The latter are more costly than other instruments, so they will be particularly useful if there is a very large spread of energy efficiencies in the market and, hence, large energy cost savings are possible. In addition, they can often be limited to a certain time period (e.g., two or three years) until the market offer and demand has switched to the energy-efficient models. For low-income households, financing support may be needed to purchase very energy-efficient appliances that have a higher upfront price but pay back over their lifetime through lower energy bills.
  Policies, which can be perfectly combined with education and financial instruments, are policies addressing the life-cycle of the product including other sustainability aspects like resources, recycling and health. It is mainly for such information and financial programmes that energy efficiency funds or energy companies must contribute.

- Education and training of professionals (manufacturers, sales staff, and other relevant market actors) should prepare introduction and further strengthening of MEPS regulation. Certification of successful participation to the training can make it more attractive for both the qualified market actors and their customers.

- Once a certain market share of (highly) energy-efficient appliances is reached, the professionals are trained and used to selling the energy-efficient models, and the cost-effectiveness of the next step is proven, then this level can then be mandated by the regulation to become the new MEPS level.

- Future steps of MEPS regulation towards very energy-efficient appliances should be prepared by innovation support through R&D funding, award competitions, and maybe also already by financial incentives for broad market introduction. The public sector should lead by example through energy-efficient public procurement, thereby paving the way for the other sectors to follow. To push the market further towards energy-efficient appliances and create first markets for them, co-operative procurement programmes can make an important contribution towards very efficient products due to the high purchasing power. Voluntary agreements with large buyers to purchase more energy efficiently than required by MEPS may also support market introduction.

The following figure illustrates exemplarily a comprehensive policy package for appliances and describes the interactions between minimum energy performance standards, energy labels, financial incentives, energy-efficient procurement, RD&D (Research, development and demonstration) promotion as well as education and training programmes.

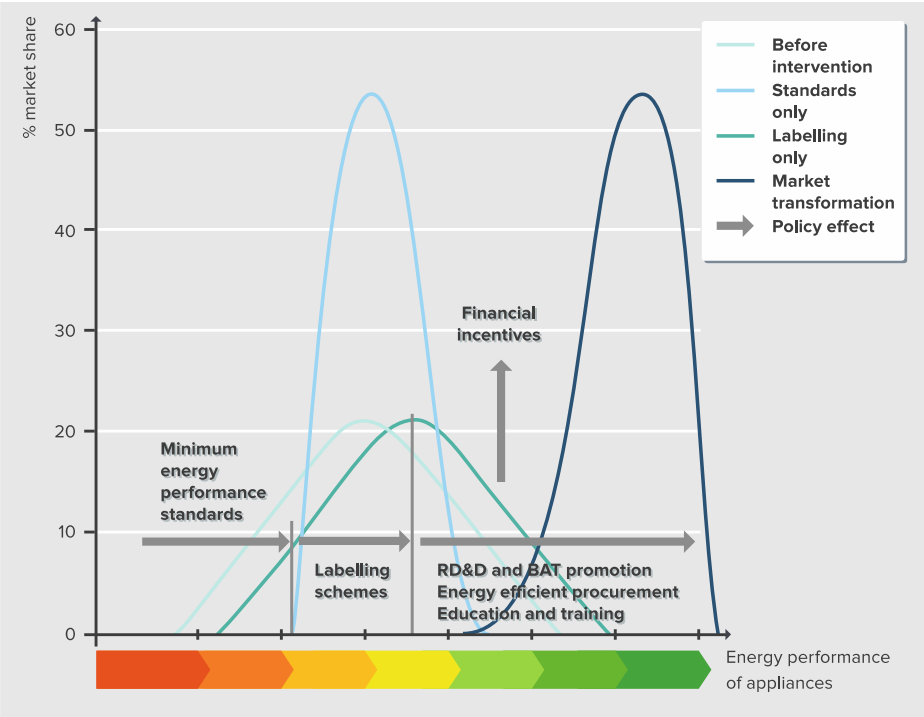

Figure 1: The interaction of policy instruments for energy efficiency in appliances

Source: Wuppertal Institute 2012

Model examples of good practice policy packages

The next step of our above mentioned methodology was to find out whether the results of our theoretical analysis are consistent with actually implemented examples of successfully operating policy packages. Consequently, we had to search for empirical evidence of good practice packages in pro-active countries. This next step was therefore the analysis of the policy packages that a number of countries have actually implemented to provide the empirical proof. Therefore the country analysis was to check whether the main elements of the theoretically adequate policy package can indeed be found in real life in the policy packages of advanced countries, so as to confirm the composition of the package. However, this does not yet include an assessment of whether all of the policy elements these countries have combined to their package are good practice for themselves.

This search started from a number of publicly available databases (such as International Energy Agency, World Energy Council, the EU project ODYSSEE-MURE[2]) and was continued with in-depth literature review on candidates identified by the team and international experts we approached for advice.

As some pro-active countries show (cf. Table 1), the policy package that we derived from our actor-centred analysis is exactly what these countries have introduced to approach very high levels of energy efficiency in appliances. These can be considered good practice for the consistent packaging of policies; however, more research is needed to analyse whether each element is a “good practice” policy of its kind and which country has achieved the biggest progress towards very energy-efficient appliances. The table can thus not be read as giving any statement on these further questions.

Table 1: Comparing the recommended policy package with good practice from four countries

Category of policies and measures	Subcategory of policies and measures	Implementation in California, USA	Implementation in China	Implementation in Brazil	Implementation in Japan
Governance framework					

[2] www.iea.org/policiesandmeasures/energyefficiency/ ; www.wec-poliicies.enerdata.eu ; www.odyssee-indicators.org

Energy efficiency targets and planning	Policy roadmap and targets for very efficient appliances	Assembly Bill 32, Climate Change Scoping Plan and Long Term Energy Efficiency Strategic Plan (Updated 2011)	China has a programme for mandatory minimum efficiency standards	National energy plan 2030, the Energy Efficiency Act	Basic Energy Plan, Energy Conservation Law
	International cooperation	California is part of the Western Climate Initiative, Co-operation with the Province of Jiangsu in China	China cooperates with the US Environmental Agency and with the Energy Management Corporation of South Korea	International organisations helped raise the profile of energy efficiency, substantial contributions from other countries	Japan is member of the IPEEC, EMAK, GSEP, Green Purchasing Network, JICA organises several activities
Infra-structure and funding for energy efficiency programmes and policy	Energy agencies	State level: California Energy Commission and California Public Utilities Commission; Federal level: Environmental Protection Agency, Department of Energy	National Development and Reform Commission (NDRC)	National Electrical Agency	Agency for Natural Resources and Energy (ANRE) Energy Conservation Centre of Japan (ECCJ)
	Overall co-ordination and financing	Each utility company must provide energy efficiency programmes and services: Energy Efficiency Portfolios and Budgets approved by the California Public Utilities Commission; Public Goods Charge	The Ministry of Finance is the key player in terms of funding; NDRC, CNIS and CSC are also instrumental for implementation	There are different financing schemes: Funding comes from the Public Benefits Funds, ELECTROBAS, the ANEEL Energy Efficiency Programme, PROESCO and other programmes to support energy efficiency	ANRE, ECCJ, NEDO agencies and budget by METI
Eliminating distortions	Removal/reduction of subsidies on end-user energy prices and on energy supply (if they exist); Energy/ CO_2 taxation and emissions trading	The electricity rate is divided into tiers	China plans to gradually implement a carbon trading system from 2013 on		There are some energy taxes but not a emission trading or a carbon tax
	Regulation of energy companies	Cost recovery of energy efficiency programme costs plus performance-based incentives; Decoupling of energy company profits from sales;		Regulatory supervision of the use of the Public Benefits Funds;	
Specific policies and measures					
Regulation	Minimum energy performance standards (MEPS)	MEPS were implemented in 1977; currently "2010 Appliance Efficiency Regulation"	China has a programme for mandatory minimum efficiency standards	Federal Law 10.295 MEPS	
	Other legal requirements				Top Runner Program, Home Appliance Recycling Law, Agreement to reduce stand-by power consumption
Information	Mandatory labelling scheme	Energy Guide	Energy Information Label	Mandatory A-G labelling scheme, Energy Standard Information System	Uniform Energy Saving Label

				(ESIS)	
	Voluntary labelling scheme	ENERGY STAR	Voluntary Energy Efficiency Endorsement Label	Voluntary labelling scheme PROCEL	Energy labelling programme; ENERGY STAR for office equipment
	Provision of targeted information	Product database for customers ENERGY STAR programmes, Flex your power	EE Information week, consumer education programme, online appliance databases	PROCEL provides relevant information on experiences and success	School programmes, training courses, up-to-date information, "Energy efficient household appliance forum", product database
	Feedback and other measures targeting user behaviour	Opower			Energy Conservation Navi Smart Life
Financial incentives and financing	Financial incentives	Financial incentives are given by both private and public energy companies. For example, SCE offers a rebate on refrigerators if an ENERGY STAR product is purchased, Energy Management Assistance Program	There are plans to subsidise the purchase of energy-saving refrigerators and other appliances	Refrigerator replacement programme	Eco-Point Scheme
	Financing instruments (e.g. soft loans)				
Capacity building & networking	Education & training for supply chain actors	Training of retail sales staff (ENERGY STAR – Retailer Resources)	GEF Project: Chinese manufacturers participated in design training workshops, study tours, and expert technical assistance	PROCEL offers training courses, seminars and conferences	Energy education in schools; Training of retail sales staff by retailers under the Energy Efficient Product Retailer Assessment Program
Promotion: Research, Development & Demo and Best Available Technology	Public sector programmes ('Lead-by-example', energy-efficient public procurement)	FEMP - EEPP	In 2006 the legal requirement „Energy Efficient Products For Government Procurement" came into force	Targets for the public sector	Green Procurement Law
	Research and development funding	Public Interest Energy Research programme		The Ministry co-ordinates research and development projects	NEDO is the largest R&D management organisation, METI has some R&D programmes
	Competition and awards	SERP, Super-efficient Refrigerator Program	The GEF project introduced the „principal award" The programme also included a lottery-style purchaser award		Energy Efficient Product Retailer Assessment Program

Note: the table only shows the priority types of policies in the bigEE recommended policy package

Source: bigEE analysis (online including all types of policies and all sources at www.bigee.net)

Discussion: What the countries do vs. bigEE's recommended policy package

A look through the table confirms that the empirical evidence proves the composition of policy package developed with the actor-centred theoretical analysis and presented above to be the right combination of policies and measures.

The governance framework for energy efficiency

Although all four countries have designed a roadmap facilitating the efficient use of energy, there are some notable differences. California stands out because of its long-term commitment to decrease GHG emissions by 80% of 1990 levels by 2050 set out in the Climate Change Scoping Plan (CCSP), which together with the Long Term Energy Efficiency Strategic Plan signals reliable political support for energy efficiency. Expanding and strengthening appliance standards are considered "key elements" [12]. For the medium-term, Assembly Bill 32 legislates GHG reductions by 2020. Similarly, China has been legislating energy intensity targets since its 11th Five-Year-Plan, established 2005, which is supported by Medium and Long-Term Energy Conservation Plan. This plan, however, does not go beyond 2020. Brazil's and Japan's strategic plans cover a period until 2030.

In Brazil and China, the Ministry of Mines and Energy and National Development and Reform Commission, respectively, pave the way towards an energy-efficient future. However, at least for Brazil, there is much room more for improvement in terms of allocating financial and human resource. California's Energy Commission (CEC) was, among other things, established to promote energy efficiency through appliance standards. Together with the Utility Commission, closely supervising privately owned energy companies, CEC designs energy efficiency measures. In Japan, the Agency for Natural Resources and Energy (which is under the Ministry of Economic, Trade and Industry) and the Energy Conservation Centre of Japan are the most important actors for increasing energy efficiency.

Brazil, California, China as well as Japan have realised that market distortions negatively affect rational energy consumption. However, different approaches have been pursuit. In California utilities are required to promote energy efficiency programmes to end-users funded through the Public Goods Charge. Moreover, energy companies are obliged to participate in a cap-and-trade programme on GHG emissions, which incentivises them even more to engage in energy-efficiency measures for end-users (e.g. refrigerator rebates). Because the less energy their clients consume, the less emission certificates need to be bought. The Chinese government plans to gradually implement emissions trading system nationwide and Japan introduced the Carbon Tax in 2012, whose funds are used for energy efficiency and renewable energy measures. Through this scheme, end-users are to use energy more rationally due to increasing energy costs. Brazil's government legislated utilities to invest 0.5% of their annual net revenues in end-user programmes aimed at increasing energy efficiency. Half of that sum must be spend on low-income households

Specific policies and measures for energy efficiency in appliances

Minimum energy performance for appliances is a key issue for all four governments, stressing its significance within an appliance package. While a comparison of the country-specific standard-setting processes would go beyond the scope of this paper, a brief description of Japan's innovative Top-Runner approach seems to be appropriate. Simply put, the Top-Runner programme identifies the most efficient appliances (or the top runners) of an appliance category on the market. Their energy efficiency value is applied as a future minimum energy efficiency standard to be achieved after a transition period of three to twelve years. This period is determined by taking into account technological development forecast and the development period of products. "Because the standard is based upon data from existing products, it can be said that the standard is market driven, i.e. no standard is set that is not (yet) available in a product on the market" [10].

Each of the four governments utilises mandatory and voluntary labels in order to accelerate market transformation by providing consumers with transparent and comparable information about the energy consumption of appliances. In Japan, the most energy efficient appliances can reach five stars. Only Japan's voluntary label, which can be incorporated into the mandatory one, shows a) whether a products meets the respective standard, b) in how far (in %) the device performs better or worse than its standard and c) how much energy a given product consumes. China's label classifies appliances into five different categories, from class one (highly efficient) to class five. Similarly, Brazil scales

devices from class A (highly efficient) to class G. Both are reminiscent of the EU Energy Label and also make use of a voluntary label. The U.S. stands out because it does not incorporate a classic classification scheme. It rather focuses on the estimated annual operating costs. This suggests that the U.S. Government considers the lack of consumer information regarding the operating costs of devices a main barrier towards market transformation. On the upper end are operating costs for highly efficient devices and energy-inefficient devices (available on the market) constitute the scale's lower end. In terms of worldwide implementation, the voluntary label of the USA, the Energy Star, can be considered a huge success. Japan, the EU and other countries have made use of the Energy Star for a broad range of appliances, for office equipment, in particular. However, the Energy Star label is not very ambitious and the requirements are not based on the best products on the market. The label is also used for the public procurement in the USA but the function is mainly to set minimum energy performance standards. By this, it only cuts the most inefficient products from the market.

In order to make consumers more fully aware of energy-efficient appliances, all four governments provide information through different information campaigns. Feedback measures such as the Energy Conservation Navi in Japan or the Home Energy Report, offered by Opower in California (and other U.S. regions and countries), are to inform the end-users more comprehensively about their energy use and can be considered an asset for both cases. California, China and Brazil support or supported the purchase of some energy-efficient appliances. Particularly in Brazil, low-income households are focused on. The Japanese Eco-Points programme is like the Top-Runner approach a very innovative measure. Eco-points can be received for the purchase of appliances that, at least, score four stars on Japans mandatory energy label.

Education and Training programmes for supply chain actors are implemented in each of the four cases. However, capacity building measures in China, which were supported by the Global Environment Facility, can have a very positive effect. First, China's sales figures for the domestic market rise constantly (Fridley 2008, p.5). Second, increasing energy efficiency in products made in China, will improve energy performance of devices worldwide.

All governments also seem to acknowledge the usefulness of public sector programmes. Whereas California, China and Japan introduced public procurement law, Brazil's commitment to only "consider" energy efficiency in the procurement process appears to be a less ambitious. Research and development funding programmes are implemented in all cases but China. Regarding competition and awards, Brazil poses an exception. China, again, benefits from the GEF project, which, among other things, announced a reward of USD 1 million to the manufacturer achieving the greatest total energy savings.

Discussion: What are the achievements?

As noted before, the comparison between these four cases served as an empirical proof for the composition of the recommended policy packages for energy efficiency in appliances. Still, one question remains. Can these four cases also be considered successful in terms of energy saved? And what has been the contribution of policy packages? Unfortunately, information that would make the countries' achievements comparable is not easily available, if at all. To compare the four governments the following impact analysis focuses on cold appliances.

- Between 1977, when the USA fired the starting gun for energy-efficient policy measures, and 2001 the maximum allowed energy consumption of a typical fridge-freezer has dropped from 1,546 to 476 kWh/year. Further reductions are expected. An indicator showing the success of the policy package may also be the stabilisation of electricity consumption (per capita) at around 7,000 KWh since 1978. This stagnation contradicts electricity consumption of the USA in general (1978: ~9,000 kWh/capita, 2008: 12,000 kWh/capita) [3].

- With regard to China, the bigEE-analysis focused on refrigerators, freezers and combinations of the two. Sales figures rose from 360,000 devices in 1999 to 46 million in 2008. Between 2008 and 2010 the market share of Grade 1 appliances increased dramatically from below 10% to 77%. As far as China's mandatory energy label is concerned, it is estimated to have the potential to save more than 16 TWh by 2020 alone [5]. Due to continuous economic growth, that may become more inclusive in the near future, sales figures for appliances are

likely to rise, which makes a comprehensive policy package aimed at reducing energy consumption of appliances even more important.

- The Brazilian government achieved to reduce the average energy consumption of new refrigerators from 491.3 kWh/yr to 270.4 kWh/yr between 1990 and 2005 [1]. Moreover, regarding the Brazil's voluntary label, PROCEL, established in 1993, saved 22 billion KWh by mid-2008 [9].

- With the Top Runner Program, Japan achieved an energy efficiency improvement rate of 55.2% from fiscal year (FY) 1998 (647.3kWh/yr) till FY 2004 (290.3 kWh/yr) for electric refrigerators. The expected average energy consumption for the target year for refrigerators was 449.7 kWh/yr [13]. For 2010, a study expected further energy savings of 21% for refrigerators and 12.7% for freezers compared to 2005 levels. Actual efficiency improvement is 43.0% from FY 2005 (572kwh/yr) to FY2010 (326kwh/yr) especially for large refrigerators and 24.9% for freezers.

Information on impacts resulting from energy-efficient policies and policy packages, in particular, are highly diverse. However, the cases discussed have implemented a broad range of policy instruments that are necessary to overcome barriers and strengthen incentives to achieve an energy-efficient appliance stock. As has been shown, developed and developing countries can make such important steps. However, more needs to be done and, hopefully, bigee.net can guide future measures for an energy efficient future.

Conclusion

With the two-pillar approach to policy analysis used here, we have been able to add new foundation, both theoretical and empirical, to the conclusion about what is a necessary and advisable package of policies to effectively advance high energy efficiency improvements in appliance:

As the first pillar, the actor-centred approach to policy analysis has confirmed our presumption that there is not one silver bullet that will kick-start a real energy efficiency transformation in the appliance sector. What is urgently needed are consistent packages of policies and measures, carefully tailored to the needs and incentive structures of all actors in the appliance value chain. Our theoretical analysis along this value chain has given us good insight as to which implementation strategies can successfully tackle the many existing barriers and which combinations of policies are needed to put these strategies into practice. The first important result is thus the policy packages we now recommend on bigee.net. There are sometimes alternative policies for one strategy, so the final composition of the package will depend on the circumstances in a specific country.

As a secondary result, we have also advanced the methodology that governments and consultants can use to assess given appliance markets and the policy support that all relevant actors need to harness energy efficiency.

As the second pillar, we also ascertained that the main elements of the theoretically adequate policy package could indeed be found in real life in the policy packages of advanced countries. This does not yet include an assessment of whether all of the policy elements these countries have combined to their package are good practice for themselves. But it confirms the composition of the package.

During our research on such model examples, we found, however, that the lack of thoroughly documented and evaluated policies and measures (both for single policies and for sectoral policy packages) makes the search for good practice quite difficult. Accordingly, resulting from our analysis there are two key messages for policy makers planning to implement a new policy or measure: it is crucial already in the policy design phase to bear in mind both the actors concerned and the data needs and other requirements in terms of monitoring and evaluation of the impacts, costs and benefits as well as for compliance with the policy, in order to ensure its effectiveness.

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